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(71) Applicant(s)
Bath Scientific Limited

(Incorporated in the United Kingdom)

Lysander Road, Bowerhill Estate, Melksham, Wiltshire, SN12 6SP, United Kingdom

(72) Inventor(s)
Vivian Charles Watts
Clive Richard Shipley
Robert Naylor

(74) Agent and/or Address for Service
Brookes & Martin
High Holborn House, 52-54 High Holborn, LONDON, WC1V 6SE, United Kingdom

(54) Electrical test apparatus with individually actuable probes

(57) Apparatus for testing products with electrically interconnected networks comprises a plurality of probes 11 arranged in rows and columns and carried by support means 10. The probes 11 have contact tips 8 capable of making selected electrical connection with connection zones of the networks and rows and columns 12 establish contact with the probes for testing purposes. Means, such as heating elements, selectively actuate the contact tip 8 of each probe under control accessed via the rows and columns 13 to cause the selected contact tips to be displaced away from the support means to establish contact with some of the connection zones. Preferably each probe 11 is formed from materials with a different expansion coefficients, such as metals, which are arranged in a spiral and act like a bimetallic thermostat when heated to cause expansion of the probes along a predetermined direction.

FIG. 1.

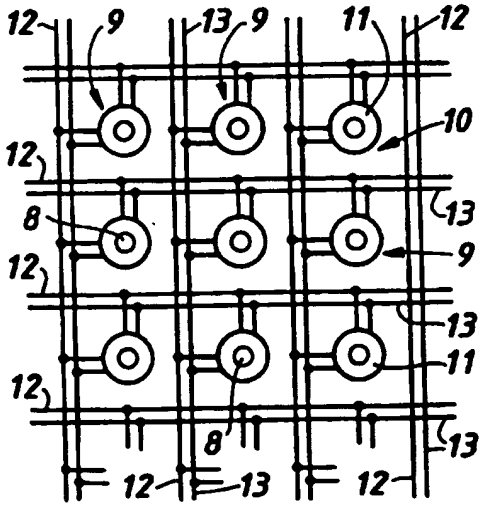
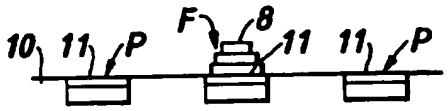


FIG. 3.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1995

FIG.1.

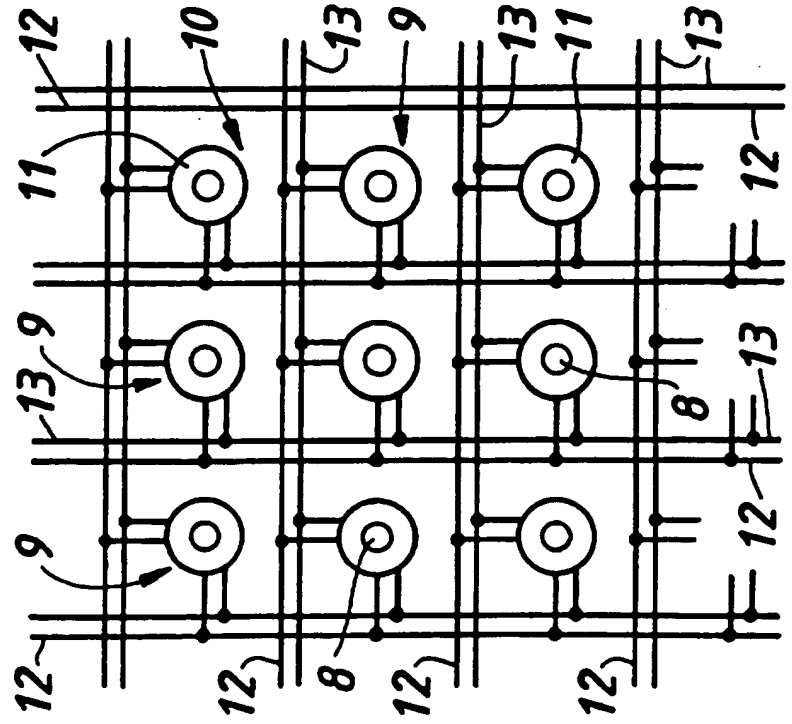
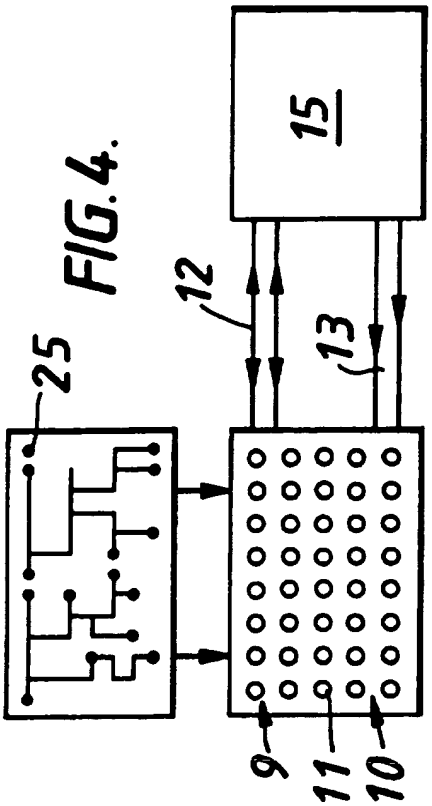


FIG.2.

FIG.3.

FIG.4.



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APPARATUS FOR TESTING PRODUCTS WITH ELECTRICALLY INTERCONNECTED NETWORKS

The present invention relates to apparatus for testing products with electrically interconnected circuits or networks. Such networks can be isolated from one another but this need not always be the case. Examples of products with electrically interconnected networks are:

1. printed circuit boards
2. printed wire boards
3. flexible circuit boards
4. ceramic substrates
5. silicon wafers
6. multi-chip modules
7. cables
8. integrated circuits either in wafer or individual die form

Hitherto, in order to test the electrical characteristics of networks of products, such as those listed above, it has been necessary to adopt testing apparatus adapted to make selective connection with the networks via their connections zones. Known forms of testing apparatus exist in variety of forms. For example, apparatus of the type known as a 'bed-of-nails' is composed of a multiplicity of probes mounted in fixed

or pre-set positions on a common rigid holder or carrier such as a board. Each probe has a spring-loaded support which urges a contact outwardly and axially of the spring into contact with selected connection zones of the networks under test. Switching circuitry then applies signals to selected probes in sequence to effect electrical test routines. In another known type of apparatus a pair of probes are moved from one location to another to make contact with the connection zones in an analogous controlled sequence.

Several variations of the basic probe design are also known. For example, the support which is used to exert force on the contact of the probe need not have its axis perpendicular to the board and the connection zones of the networks under test but instead is offset and acts like a cantilever to exert the force on the probe contact by bending.

The main common support or carrier for the probes needs to be adapted to the physical locations of the electrical connection zones of the networks which do vary. The main support and the probes can be pre-conditioned for a particular product under test. Alternatively, the main support may have probe locations laid out in a regular grid pattern with rows and columns and the product also needs the networks and connection zones generally to conform with the same grid pattern. The individual probes are then mounted on the main

support in the correct locations as defined by the product.

In the known apparatuses, each probe needs to exert a certain compressive force on its contact to establish a good electrical connection with the connection zone of the product. In modern products, the number of connection zones typically amount to several thousands and the total force exerted on the product by the probe contact can be considerable. Spring-loaded coaxial probes cannot be manufactured in practice with their centres on a grid with interspacing below 250 microns since the physical nature of the mechanical springs limits the density of the probe centres.

Although the cantilevered supports do not suffer from the same limitation the necessary electrical connection to the probes and the additional space needed to accommodate the angular deflection of the support are limitations in practice and these probes are really only useful with a limited number of connections in a given area.

A general object of the present invention is to provide an improved apparatus for testing products with electrically interconnected networks.

According to one aspect of the invention apparatus for testing products with electrically interconnected networks comprises a plurality of probes carried by support means, the probes having contacts capable of

making selective electrical connection with connection zones of the networks, means for selectively actuating the contact of each probe to cause the contact to be displaced away from the support means to establish contact with one of the connection zones and control means for controlling the operation of the actuating means so that the individual probes may have their contacts displaced into contact with or not into contact with the associated connection zones.

The probes can be laid out on the support means as a grid or array of cells in columns and rows. The control means may then also comprise, at least partly, bus lines so that the individual probes can be addressed and actuated and electrical signals routed to and from selected probes. The probes are preferably constructed so that when the associated actuating means is not operated the contact of that probe returns automatically to a rest position out of contact with the associated connection zone.

In one embodiment of the invention the actuating means operates physically or mechanically and the control means operates electrically to operate the actuating means. The actuating means can then be micro-engineering components with gears, levers and electrical motors and the control means would provide the electrical energy to operate these micro components.

In a preferred design however each actuating means

operates electrically to make the associated probe contact displace. This electrical function can be achieved by converting electrical energy into heat to cause the probe or part of the probe to expand.

In one embodiment described hereinafter each probe is formed from materials with different expansion coefficients, such as metal strips, which act like a thermostat when heated to cause expansion of the probe along one pre-determined direction. This direction can be perpendicular to the support means but this is not essential.

In another aspect the invention provides a support or substrate carrying a plurality of cells arranged in columns and rows, each cell being addressable via the columns and rows, wherein each cell is composed of a probe and a probe actuating means each probe having a contact displaceable in relation to the support between an operative position for contacting an external connection zone of an electrical network of a product under test and an inoperative position and the displacement of the probe contact being effected by operation of the probe actuating means.

The support or substrate can also be formed with buses for addressing selected probe contacts to apply signals thereto for testing of the product and for addressing the associated probe actuating means to cause the displacement of the selected probe contacts to their

operative position.

The invention may be understood more readily, and various other aspects and features of the invention may become apparent, from consideration of the following description.

Embodiments of the invention will now be described, by way of examples only, with reference to the accompanying drawings wherein:

Figure 1 is a schematic plan view of part of an apparatus constructed in accordance with the invention;

Figure 2 is a schematic sectional side view of the part apparatus shown in Figure 1;

Figure 3 depicts one of the probes of the apparatus and

Figure 4 is a block diagram showing the main operating components of the apparatus.

As shown in Figures 1 and 2, apparatus constructed in accordance with the invention comprises a support in the form of a board or substrate 10 on which is mounted or defined a plurality of individual cells 9 with probes 11. The cells 9 are arranged as an array of columns and rows so each individual cell 9 can be addressed by a row and column. The probe 11 of each cell 9 is adapted to contact some other external connection zone of an electrical network selectively in order to effect electrical test procedures. To achieve this, each probe 11 has a contact-forming tip 8 which can be

displaced between an operative position where it physically contacts the external connection zone and a non-operative position where no contact is made with the external connection zone.

In order to displace the tip 8 between its operative and inoperative positions the probe 11 is operably associated with actuating means. In one constructional form each probe 11 is formed from materials with different expansion coefficients, for example, iron and copper, as represented by reference 15 in Figure 2. The different materials 15 may be arranged as strips in a loop or spiral as shown but the exact configuration can vary and the spiral is merely illustrative.

Each probe 11 is then provided with its own actuating means in the form of a heating element (not shown). The heating element can be incorporated with the materials 15. The probes 11 and the heating elements can be addressed by the associated row and column when it is desired to actuate the associate probe or probes 11 and to effect the electrical testing. When the heating element of a selected probe 11 is energised the materials 15 expand and the probe 11 changes from a planar form designated P in Figure 3 into a frusto-conical shape designed F in Figure 3. The probe 11 thus caused to adopt the form F extends outwardly from the substrate 10 and its tip 8, acting as a contact, engages

with the external connection zone under test. When the heating element associated with the selected probe 11 is de-energised the materials 15 contract again and the probe 11 again adopts the planar form P. The probes 11 can be fabricated onto a substrate 10 of silicon by etching and deposition in known manner. The cells 9 can be fabricated with interspacing less than 250 microns.

In addition as shown in Figure 1 the substrate 10 carries two separate networks of column and row buses designated 12 and 13. The bus network 12 serves to establish electrical connection with a selected probe or probes 11 for testing purposes whilst the bus network 13 serves to energize the associated heating element or elements.

As shown in Figure 4, the bus networks 12, 13 are connected to a control means 15, conveniently a computer, which serves to actuate the heating elements of the probes 11 of selected cells 9 in accordance with a program in order to cause the probes 11 to adopt their operative positions in a predetermined sequence to contact electrical connection zones of the electrical networks of the product under test designated 25. The control means 15 also applies electrical signals to the appropriate active probes 11 to effect electrical test routines on the networks of the product under test 25 and the results of these tests are stored in a memory of the control means 15 and used for further processing of the

test results.

In a modified arrangement the bus network 13 for energizing the heating elements is itself formed with restrictive tracks acting as the heating elements on the substrate 10 which surround or partly surround or which overlap or partly overlap the probes 11 or otherwise are in close proximity to the probes 11.

Claims

1. Apparatus for testing products with electrically interconnected networks comprising a plurality of probes carried by support means, the probes having contacts capable of making selected electrical connection with connection zones of the networks, means for selectively actuating the contact of each probe to cause the contact to be displaced away from the support means to establish contact with one of the connection zones and control means for controlling the operation of the actuating means so that the individual probes may have their contact displaced into contact with or not into contact with the associated connection zones.

2. Apparatus according to claim 1, wherein the probes are laid out on the support means as a grid of cells in columns and rows.

3. Apparatus according to one of the claims 1 or 2, wherein the control means at least partly comprises bus lines so that the individual probes can be accessed and actuated and electrical signals routed to and from selected probes.

4. Apparatus according to any one of the claims 1 to 3, wherein the probes are constructed in such a way that when the associated actuating means is not operated the contact of the respective probe returns automatically to

a rest position out of contact with the associated connection zone.

5. Apparatus according to any one of the claims 1 to 4, wherein the actuating means operate physically or mechanically and the control means operate electrically to operate the actuating means.

6. Apparatus according to any one of claims 1 to 4, wherein the actuating means are micro engineered components with gears, levers and electrical motors and the control means provide the electrical energy to operate the micro components.

7. Apparatus according to any one of claims 1 to 4, wherein the actuating means operate electrically.

8. Apparatus according to claim 7, wherein the electrical function is achieved by converting electrical energy into heat to cause the probe or part of the probe to expand.

9. Apparatus according to any one of the preceding claims wherein each probe is formed from materials with different expansion co-efficient causing expansion of the probe along one predetermined direction when heated.

10. Apparatus according to claim 9, wherein the probes are formed from metal strips.

11. Apparatus according to any one of the preceding claims, wherein the direction of expansion of the probe is perpendicular to the support means.

12. A support or substrate carrying a plurality of

cells arranged in columns and rows, each cell being addressable via the columns and rows, wherein each cell is composed of a probe and a probe actuating means, each probe having a contact displaceable in relation to the support between an operated position for contacting an external connection zone of an electrical network of a product under test and an in-operative position and the displacement of the probe contact being effected by operation of the probe actuating means.

13. A support according to claim 12, which is formed with buses for addressing selected probe contacts to apply signals thereto for testing of the product and for addressing the associated probe actuating means to cause the displacement of the selected probe contacts to their operative position.

14. Apparatus substantially as described with reference to and as illustrated in any one or more of the Figures of the accompanying drawings.

15. A support or substrate for use in the apparatus according to any one of claims 1 to 11 and substantially as described with reference to and as illustrated in Figures 1,2 and 3 of the accompanying drawings.

The Patent Office

Application No:	GB 9420972.3	**Examiner:**	David Mobbs
Claims searched:	1-15	**Date of search:**	20 December 1995

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): H2E EAHB, EAHC, EAHG

Int Cl (Ed.6): G01R

Other: NONE

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X, Y	GB 1,316,108	BRITISH AIRCRAFT CORPORATION - see particularly page 2 lines 41-46.	X: 1, 2, 4-5, 11 Y: 3
X, Y	US 5,124,646	TOSHIBA	X: 1, 2, 4, 11 Y: 3

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.